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DATA REDUCTION AND ANALYSIS FROM THE SOHO SPACECRAFT

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Instrumentation

The Mass-determining Time-of-Flight (MTOF) instrument is a modified, improved version of the "MASS" instrument flown on the WIND mission, and was built by the University of Maryland (UMD). The unique entrance system was built at the University of Bern (UBE) in Switzerland. Along with the Charge Determining Time-of-Flight (CTOF) and Suprathermal Time-of-Flight (STOF) instruments, MTOF is a part of the Charge, Element, and Isotope Analysis System (CELIAS). The Mass-determining Time-of-Flight sensor on SoHO is designed for the precise determination of the chemical and isotopic composition of the solar wind over a wide range of solar wind conditions. MTOF can measure the chemical and isotopic composition of the solar wind for most elements with mass ≤ 70 or so. MTOF uses electrostatic analysis followed by a time-of-flight measurement in a specially designed harmonic potential.

The Proton Monitor (PM) is a subsensor of the MTOF instrument, which is one of the 3 time-of-flight instruments comprising the CELIAS experiment. MTOF determines high-resolution mass spectra of heavy solar wind ions and uses a very wide bandwidth energy-per-charge analyzer to maximize counting statistics. The PM was designed to assist in the interpretation of MTOF data and for that reason uses a similar wide bandwidth analyzer that limits the accuracy of derived solar wind parameters.

Health of Instrument

We routinely monitor the health of the MTOF instrument, and support the various spacecraft maneuvers with appropriate command sessions to reduce our high voltages during thruster burns, followed by re-establishing the nominal mode for MTOF.

Every day at noon, a pair of programs is automatically run on the latest files received from the Experiment Operations Facility (EOF). These programs write housekeeping and rate information to ASCII files that are then sent via electronic mail to several members of our group. Visual examination of these files provides a check on instrument health, and could give rapid warning if an instrument problem were to arise. Another program that is automatically run at noon each day generates a binary file of rate information suitable for analysis on a Macintosh.

In order to monitor the health of the instrument and the quality of the data in the longer term, six programs are run each day that read the most recent Level Zero file. Two of these programs generate files of rate information for both the MTOF main sensor and the PM subsensor. Two others generate files containing instrument status and housekeeping information. Another program finds the minimum and maximum values of various housekeeping quantities, and still another generates a binary file of rate information suitable for analysis on a Macintosh. The ASCII files generated by the first five programs are stored on line and also printed and kept in binders. This allows easy access to housekeeping, status, and rate information for the entire mission.

Flight operations for the CELIAS experiment during the reporting period (November 1996 to October 1999) have included the following:

Safing and recovery of the MTOF, STOF, PM, and CTOF sensors during SoHO operations which involve the use of thrusters (station keeping, momentum management, and reaction wheel maintenance) These operations take place approximately every 3 months, and typically require commanding over a 4-5 day period.

Reactivation of the MTOF, STOF, PM, and CTOF sensors after the loss and recovery of the SoHO spacecraft in 1998.

Turning MTOF back on after instrument "latchups" caused the sensor to be turned off. This has happened three times to date.

Special commanding has been required for CTOF (which began experiencing problems in August 1996), and for software patches to the DPU (patches 12, 13, 14, and 15). The purpose of patch #15 is to deal with the aforementioned instrument "latchups". During a latchup condition, the main MTOF current rises to abnormally high levels. Since a latchup could occur while SoHO is not being tracked, it is possible that such high currents could persist for hours, if the patch were not in place. This would probably cause severe damage to the sensor. Patch 15 allows the CELIAS DPU to monitor the MTOF main current. If this current exceeds a given threshold value four times consecutively (indicating a latchup condition) the DPU will turn the MTOF sensor off for 5 minutes. This should clear the latchup. Then the DPU will turn the sensor back on in STANDBY mode (all high voltages off).

New TSTOL procedures have been created for the DPU, MTOF and STOF.

Documentation on the CELIAS ESR response and the MTOF emergency procedures has been supplied to the Science Operations Coordinator (SOC).

CELIAS housekeeping is processed daily and sent to MPAe, MPE, and UMD. We have responded to the FOT regarding yellow and red flags observed for CTOF, STOF, and MTOF parameters.

Solar Wind Web Page

We have also spent considerable effort in establishing and maintaining a page on the World Wide Web that presents almost real-time solar wind data from our MTOF/PM subsensor on the SoHO spacecraft. It was announced in an on-line newsletter (SPA section newsletter, Vol. 3, Issue 66) that is circulated to the space physics community. Presently, the PM page receives about 700 "hits" per day. The URL is:

`http://umtof.umd.edu/pm`

The PM web page has been continuously revised and improved. The algorithms used to derive solar wind parameters from the PM data were refined and tested over a time period of months, and the organizational structure of the web page was substantially changed. In addition, the solar wind flow angle out of the ecliptic plane was added to the list of parameters that are plotted.

The web page contains plots of solar wind parameters for the most recent 2 days of data and the most recent 2 weeks of data. The solar wind parameters plotted are bulk speed, proton density, thermal speed, and angle out of the ecliptic plane. The current location of the SoHO spacecraft, taken from predicted orbit files, is also displayed on the page.

Links on the page lead to: descriptions of the plotted parameters and the PM sensor; older data organized by Carrington Rotation; older orbit data; an "interesting figures" page where we have expanded scale plots of e.g. shocks, high speed streams, low density time periods, etc; and an incomplete "shock table" listing solar, interplanetary, and magnetospheric conditions near the time of shocks observed by the PM. The older PM data is available in the form of tables of ASCII data and also in the form of plots. The older orbit data is a plain text table.

Data files are transferred electronically via FTP from the EOF to the UMTOF system at Maryland. The PM page is updated automatically within a few

minutes of the receipt of a file from the EOF. The data is processed using a FORTRAN program and new plots are generated by IDL as needed; human intervention is not required.

SoHO is never in the magnetosphere and enjoys excellent data coverage. The data on the Web page are typically between a few minutes and a few hours old.

We have also responded to numerous requests for PM data made by members of the scientific community around the world.

Data Analysis

A large number of programs have been written to assist in data analysis. These programs are described in Appendix C. To facilitate use of these programs, considerable effort was made to provide online documentation available via the World Wide Web. This documentation consists of almost 300 files, containing over 2.3 megabytes of information.

An automated routine (called "Shockspotter") that searches the PM data for shocks is in development, and is currently being tested. The algorithm is being fine-tuned to minimize the number of false positives and false negatives.

Science

We continue to analyze and interpret data from the MTOF sensor on SoHO, using recently obtained calibration data (from the MTOF spare) to improve our understanding of instrument response. We have presented a number of talks demonstrating the excellent instrument resolution and also displaying the temporal behavior of solar wind Fe^{54} and Fe^{56} isotopes and the element Cr(52). In addition, the isotopic ratios $Ne^{20}/Ne^{22} = (13.8 \pm 0.7)$ and $Ne^{20}/Ne^{21} = (440 \pm 110)$ were obtained from MTOF data. These ratios agree with the values obtained from the Apollo foil solar wind experiments and with values that have been derived from measurements on lunar and meteoritic samples.

Peter Bochsler (CELIAS P.I.) of the University of Bern in Switzerland spent his sabbatical at the University of Maryland. Professor Bochsler assisted in the development of MTOF analysis procedures, lending his expertise in several areas. These included charge state yields and scattering of ions traversing the Carbon foil in the TOF sensor, and the theoretically expected abundances and charge states of ions in different solar wind flow types.

In order to derive more precise instrument efficiencies, we took the MTOF spare sensor to the University of Bern in Switzerland for additional calibration. There were two trips. The first was undertaken in 1998. The duration of the trip was from March 21 to April 3 1998. The CASYMS accelerator at Bern is capable of producing beams of a variety of elements and energies. We used beams of He^+, O^+, and Ar^+, with beam energies ranging from as low as 0.7 keV for Helium to as high as 60 keV for Argon. By removing the deflection system for a portion of the calibration, we were able to obtain information about the contributions to the overall efficiency due to the time-of-flight system alone, as well as the sensor as a whole. The second trip lasted from October 1 to October 21 1999. The MEFISTO accelerator at Bern is capable of producing beams of a variety of elements, energies, and charge states, including such elements as iron and calcium, which are unavailable at other accelerators. By removing the deflection system for the calibration, we obtained information about the contributions to the overall efficiency due to the time-of-flight system alone.

Talks on CELIAS were given at a variety of venues, including the AAAS Meeting in Seattle, IAGA in Uppsala, the Solar Wind 9 Meeting in Nantucket, the AGU Spring Meetings in Baltimore and Boston, the 7th and 8th SoHO Workshops (in Northeast Harbor, Maine and in Paris, respectively), and the 24th EGS General Assembly in The Hague. Papers have been submitted to the Journal of Geophysical Research, to Solar Physics, and to GRL. The talks and papers are listed in a complete bibliography accompanying this report as Appendix D.

The first determination of the Na abundance in the solar wind was reported at the Spring AGU meeting. Na with its 5.12 V First Ionization Potential (FIP) is the most extreme low-FIP element observed in the solar wind to date. The proximity of Na to Ne in mass as well as the similar and narrow charge state distributions of Na and Ne in the corona render these two elements as almost ideal markers to accurately identify small variations between low- and high-FIP solar wind with CELIAS/MTOF. The short first ionization time of Na and the relation of the solar wind Na abundance to a very well known photospheric value make it a prime candidate for investigating coronal-hole associated FIP fractionation and for sensitive testing of FIP/FIT models. The behavior of Na relative to low-FIP and high-FIP elements was compared, for both interstream and coronal-hole associated solar wind flows. Preliminary results indicated that Na behaves as expected for a low-FIP element in these two types of solar wind flows.

The first determination of the Al abundance in the solar wind, obtained with CELIAS/MTOF, was also reported at the AGU meeting. The analysis covered two short periods in November 1998. The solar wind Al abundance is particularly interesting, because of the extremely short ionization time of this element under normal chromospheric conditions. The Al abundance has been evaluated in comparison with the neighboring low-FIP element Mg. A preliminary evaluation yielded an Al/Mg abundance ratio of 0.088 for the interstream period and a ratio of 0.086 for a period of coronal hole associated solar wind. Within the estimated uncertainties of less than 20% these ratios are consistent with each other, and also compatible with the photospheric and the meteoritic abundance ratios. At the same time the normal bias between low- and high-FIP elements is confirmed for the periods of investigation. Hence, Al, which ionizes much faster than Mg under chromospheric conditions, shows no deviation in its abundance from the other low-FIP elements for the two investigated periods.

In addition, we made a pair of collaborative studies, together with the SWICS sensor on the ACE spacecraft. In the first of these, we used combined measurements from ACE/SWICS and SOHO/MTOF to investigate the onset of a well defined coronal hole-associated high speed stream on DOY 69, 1998. The SWICS O7/O6 ratio shows that the transition from slow to high-speed solar wind flow was relatively abrupt (less than 2 hours), while the transition back to slow wind was much broader (a few days). The density pile-up region preceding the coronal hole flow had typical low-speed charge states. The precipitous drop in the Oxygen ionization temperature was accompanied by an increase in the solar wind bulk and thermal speeds, a decrease in density, and an enhanced velocity and temperature difference between the solar wind Protons and Alpha Particles. The Fe isotope ratios remained unchanged throughout these transitions. In the second collaboration, we used combined measurements from ACE/SWICS and SOHO/MTOF to investigate the behavior of Iron during the unusual CME of May 2 and 3, 1998. We found a surprisingly large distribution of Fe charge states, ranging from +3 to at least +16, with the lowest and highest charge states occasionally observed simultaneously. To our knowledge these are the first measurements of Fe+3 in the solar wind. In contrast to the charge state distributions, the Fe isotope ratio remained constant with a value very close to its meteoritic ratio.

Appendix A: Routine SOHO Tasks

This document lists those automated SOHO science tasks that are performed on a regular basis on the UMTOF system at the University of Maryland.

The science oriented tasks, which consist mainly of the procedure SOHO_DAILY being run in one its two modes (SUITE1 and SUITE2), are performed daily.

Another set of tasks is done regularly and with varying frequency to maintain the Proton Monitor (PM) home page on UMTOF. For details on how the output of these procedures and programs are put together, see a separate article on how the PM home page is constructed.

Routine SOHO Science Tasks

Below is a list of tasks performed on a regular basis. Unless noted otherwise the task is performed once each day.

Task	What Is Done
SOHO_DAILY (LATESTLZ)	Run a suite of programs to process the latest SOHO LZ files and create binary files which can be viewed on a Mac.
SOHO_DAILY (LATESTEOF)	Run a suite of programs to process the latest SOHO REL/QKL file and create a Mac binary file for it. Mail ASCII output of programs to selected users. Perform other housekeeping tasks.
RECENT48	Check if there are any new quicklook data. If so, generate a new 48-hour PM plot and update the PM home page. This checks for new files every five minutes.
RECENT_2WEEK	Generate 14-day PM plot, update PM home page.
CRN	Generate a new or updated plot of PM data for a Carrington Rotation period. Update web pages to point to new plot. This runs approximately every 14 days.
LOG_SOHO_POSITION_NEW	Obtain and record the SOHO spacecraft's position information and other information. These items of data are used by RECENT48 and RECENT_2WEEK.
SPLIT_QKL	Locate data gaps in QKL (quicklook) data files, split QKL files into smaller files without gaps. This is done every 12 hours.
MASTER_CH	Change format of recent (within the last 3 days) Command History (CH) files, extract certain Command History records, and append them to the file MASTER_CH.DAT
CHECK_ROLL_NEW	Read latest attitude file and check if roll angle is outside acceptable limits.
SOHO_NIGHTLY	Perform various file maintenance tasks, such as purging and deleting certain files.

Appendix B: SOHO Science Procedures on the UMTOF System

This document gives information on SOHO data processing procedures used at the University of Maryland at College Park UMTOF system. It is divided into three sections:

Detail Description of SOHO Procedures

Procedure: SOHO_DAILY (LATESTLZ)

Purpose:

Process recent SOHO LZ files, creating ASCII and Mac binary files. Write all output files to DISKM4:[DAILY]. Print all ASCII output files to UMTOF printer.

When run: each day at 06:00

Programs run:

EDB	process latest LZ science file, create Mac binary file
DUMMY	process latest LZ science file, create ASCII output file
RATES	process latest LZ science file, create ASCII output file
PMRATES	process latest LZ science file, create ASCII output file
HK	process latest LZ HK file, create ASCII output file
HK_MINMAX	process latest LZ HK file, create ASCII output file

Data sets:

Science and housekeeping LZ files copied to the system since 6:00 of the preceding day. Specifically, all .DAT1 files (both G029 and G013) in SOHO_LZ_DATA: whose modification date is later than 6:00 of the preceding day.

Procedure: SOHO_DAILY (LATESTEOF)

Purpose:

Process latest EOF data, create Mac binary file, extract rate and housekeeping information, and email it to selected personnel.

When run: each day at 12:00

Programs run:

EDB	process latest EOF science, create Mac binary file
RATES	process latest EOF science, create ASCII output file
HK	process latest EOF science, create ASCII output file

Data sets:

Latest science EOF file (CELSC1_*.*) located in SOHO_EOF_DATA: with size at least 2500 blocks, and latest housekeeping (CELHK_*.*) EOF file located in SOHO_EOF_DATA with size at least 50 blocks. The latest data set is the last one reported in a DIRECTORY listing.

Procedure: CHECK_ROLL_NEW

Purpose:

Examine the attitude files and detect if the spacecraft's roll angle has exceeded its allowable range.

When run: each day at 23:30

Programs run:

CHECK_ROLL

Data sets:

SOHO definitive attitude files (SOHO_AT_DATA:SO_AT_DEF*.CDF) copied to the system since 23:30 of the preceding day. DISKM1:[SOHO]ROLL.DAT contains log of when satellite roll angle was outside of norm.

Procedure: LOG_SOHO_POSITION_NEW

Purpose:

Examine the orbit files, extract the spacecraft's position, and append it to a file. Also extract and write out the distance from the sun, the space latitude and longitude and the current Carrington Rotation number (earth). Finally, create an HTML file of the orbit information.

When run: each day at 23:30

Programs run:

LOG_SOHO_POSITION

Data sets:

Predicted orbit files (SOHO_OR_DATA:SO_OR_PRE*.CDF) copied to UMTOF since 23:30 of the preceding day. The modification date is used to select the data sets. Previously this procedure used definitive orbit files, but they are no longer generated.

Description:

The quantities GSE position (X, Y, and Z) in Earth radii, Space latitude and longitude in degrees, and Carrington Rotation Number (earth) are extracted from the second entry of each orbit file and appended to the file [SOHO]ORBIT.DAT . In addition the distance from the sun is computed and written to the file.

The file OLDORBIT.HEADER, the file ORBIT.DAT mentioned above, and the file OLDORBIT.TRAILER and concatenated and copied to the file OLDORBIT.HTML in the PM WWW area.

Procedure: MASTER_CH

Purpose:

Change the file characteristics of recently received Command History files so they can be easily examined. Extract all command history records dealing with CELIAS and append them to a master CELIAS command history log.

When run: each day at 00:00

Programs run:

SET FILE
SEARCH
APPEND

Data sets:

All command history files (SOHO_CH_DATA:SO_CH_NUL*.DAT) whose format is not StreamLF. The file format is changed to StreamLF. The file is then searched for records containing the strings " CEL" or " FB". Those records are extracted from the command history file and appended to the file SOHO_CH_DATA:MASTER_CH.DAT .

Procedure: RECENT48

Purpose:

This procedure runs as a batch job every 5 minutes. If there is new QKL or REL data it runs the program PMSW to extract the most recent 48 hours of data. It then invokes the procedure PMPLOT.COM and passes it the filename and several other parameters, requesting that it update the PM home page.

When run: every 5 minutes

Programs run:

PMSW
IDL
GET_PREDICT_POSITION
PMPLOT.COM
TIMES.PRO
PMPLOT_TICKS.PRO
PMPLOT_IO.PRO
PMPLOT_GRAPH.PRO
PMPLOT_ADJUST.PRO

PMPLOT_RANGES.PRO
PMPLOT_INIT.PRO
PMPLOT_MAIN.PRO

Data sets:

Realtime and quicklook Celias science files from the EOF facility (SOHO_EOF_DATA:CELSC1*.*) which are larger than 10 blocks and represent data from the 48 hour period just ended. Slightly more or less data may be displayed depending on the phase of the starting time of the interval (always starts on multiple of 4 hours) and the presence (or rather the absence) of data sets near then end of the interval.

Procedure: RECENT_2WEEK

Purpose:

This procedure runs as a batch job every morning at 7:00. It runs the program PMSW to extract the most recent 14 days of data. It then invokes the procedure PMPLOT.COM and passes it the filename and several other parameters, requesting that it update the PM home page.

When run: each day at 07:00

Programs run:

PMSW
IDL
PMPLOT.COM
TIMES.PRO
PMPLOT_TICKS.PRO
PMPLOT_IO.PRO
PMPLOT_GRAPH.PRO
PMPLOT_ADJUST.PRO
PMPLOT_RANGES.PRO
PMPLOT_INIT.PRO
PMPLOT_MAIN.PRO

Data sets:

Realtime and quicklook Celias science files from the EOF facility and Level Zero (LZ) science files from the ISTP facility which represent data from the 14 day interval just ended. Intervals always start at 0000 GMT.

Procedure: CRN

Purpose:

Generate plots of PM quantities based on Carrington Rotation instead of an arbitrary calendar period. Each plot is generated four times as additional/more reliable data becomes available.

When run: approximately every 14 days at 1:23
more precisely, it is run once after the start of a Carrington Rotation period and once at the midpoint of the rotation period

Programs run:

CRN_PLOT.COM
PMSW
IDL
PMPLOT.COM
TIMES.PRO
PMPLOT_TICKS.PRO
PMPLOT_IO.PRO
PMPLOT_GRAPH.PRO
PMPLOT_ADJUST.PRO
PMPLOT_RANGES.PRO
PMPLOT_INIT.PRO
PMPLOT_MAIN.PRO

Data sets:

Each time CRN is run two plots are generated. In each case the interval (i.e., rotation period) of the first plot generated exactly matches the interval of a plot generated earlier. It replaces the earlier plot in the CRN web page.

Description:

In mode A the first plot (period AX, file suffix _A3) uses mostly Level Zero science files, but may use some realtime and quicklook Celias science files for the rotation period preceding the current period. The second plot (period AY, file suffix _A1) uses only realtime and quicklook Celias science files for the current rotation period. This generates a plot of a partial period.

In mode B the first plot (period BX, no file suffix) uses only Level Zero science files for the rotation period preceding the one just ended. The second plot (period BY, file suffix _B2) uses a combination of Level Zero, realtime, and quicklook science Celias files science files for the rotation period just ended.

Procedure: SOHO_NIGHTLY

Purpose:

Perform various maintenance tasks, such as deleting old files or data sets, and purging files which have multiple versions. Also perform certain monthly maintenance tasks, such as deleting old LZ data sets and resetting the version numbers of certain frequently used files.

When run: each day at 3:33

Programs run:

PURGE
DELETE

Data sets:

Nightly:
LZ, OR, AT, CH files which have multiple VMS versions - purge
All *.SFDU files - delete
All CELSC1 EOF files that are smaller than 10 blocks but not currently being transferred - delete
All EOF files that are more than 45 days old - delete
LZ, OR, AT files which have multiple data set versions - delete earlier version numbers
All 2-day graphs more than 2 days old - delete
All 2-week graphs more than 14 days old - delete
All full 2-week graphs and their associated image map files more than 1 day old - delete, but keep composite graphs

Monthly:
RECENT48 log files, its associated control files, PMSW.DAT, and
PMSW.USED - purge and reset version number

Procedure: SPLIT_QKL

Purpose:

Scan the EOF directory for Quicklook (*.QKL) files. For each file examine it for large data gaps (more than 1 hour). Create another, potentially two, output files to eliminate the gap. Two output files are created if there is a significant (more than 5 minutes) amount of data preceding the gap. Rename all processed files into another directory for archival purposes. Change file attributes on created files so PMSW will be able to process them.

When run: every 4 hours

Programs run:

SPLIT_QKL

Data sets:

SOHO_EOF_DATA:*.QKL
Creates corresponding output files with user-specified file type; e.g.., *.MOD

Appendix C: SOHO Programs on UMTOF

This appendix describes most of the SOHO programs in use at the University of Maryland on the UMTOF system. The following notes apply to all programs:

- All executables reside in DISKM1:[SOHO.EXE], which is pointed to by the logical name SOHO_EXE: .
- Working source code for the programs is archived in DISKM1:[SOHO.SOURCE], which is pointed to by the logical name SOHO_SOURCE: .
- Source code for the object libraries which are used by the programs is archived in DISKM1:[SOHO.LIB.SOURCE].
- All output files generated by these programs which have a file type of .DAT are suitable for loading into a spreadsheet program such as KaleidaGraph. In addition they have the time in one of the columns.
- All output files generated by these programs which have a file type of .TABLE are more free format and can not be used in a spreadsheet.
- Both .DAT and .TABLE output files contain ASCII information.
- Output files having a file type of .BIN are binary files with stream-of-bytes format suitable for reading on a Mac.
- The following programs allow spanning multiple files: DUMMY, EDB, EDBPM, HEAT_CURR, HK, HK_FULL, PHATREND, PMRATES, PMRSTACK, PMRSTACKA, PMRT, PMSW, RATES, THERM2, and THERM4
- The programs that span files handle nested files appropriately.
- Most of the programs can be forced to use a specific input file by defining a logical name. This is especially useful in the event of a spacecraft problem. If the logical name SOHO_INPUT_FILE is defined, the programs will not prompt for a start or stop time, instead processing the single file specified by the logical name. The programs for which this does *not* work are HOUR_AVERAGE, LOG_SOHO_POSITION, PMOFFLINE, PMSIMEOF, PMSW_REFORMAT, SAMPLE_SW_SMS, SPLIT_QKL, STACK, and SWE_AVERAGE.

Summary of SOHO Science Programs On UMTOF

Below is a list of the programs and a brief description of each. This is followed by a more detailed description of each program.

Program Name	Purpose
C_SPEED	computes CTOF speed
DUMMY	dumps dummy EDBs
DUMP_PACKET	dumps packets
DUMP_TIMES	dumps times
EDB	reads and optionally dumps EDBs
EDBPM	reads and dumps EDBs with solar wind parameters added
HEAT_CURR	dumps currents and heater status
HK	dumps some quantities from HK packets
HK_FULL	dumps HK packets (all quantities)
HK_MINMAX	finds lowest and highest values of certain MTOF-related quantities
HOUR_AVERAGE	averages 5-minute resolution files, producing 1-hr and 2-hr averages
LOG_SOHO_POSITION	records position of SOHO satellite
PHATREND	counts PHA words in user selected region
PMOFFLINE.COM	generates PM plots without changing PM home page
PMRATES	dumps PM rates and PM E/Q values
PMRSTACK	generates stacked plots of PM counts vs. radius

PMRSTACKA	generates stacked plots of PM counts vs. radius, with altered radius bins
PMRT	dump distributions in radius and theta of PM counts
PMSIMEOF	Given 6 PM rates, write SW parameters to screen
PMSW	fits PM data and derives solar wind parameters
PMSW_REFORMAT	Reformats data files produced by PMSW
RATES	dumps rates
SAMPLE_SW_SMS	samples WIND SMS solar wind data files
SPLIT_QKL	detects large gaps in QKL files and splits them into one or two files without gaps
STACK	DCL command file to run either PMRSTACK or PMRSTACKA
SWE_AVERAGE	reads SWE KP files, generates 1-hr and 6-hr averages
THERM2	dumps temperatures from SVM HK2
THERM4	dumps temperatures from SVM HK4

Detailed Description of SOHO Science Programs on UMTOF

C_SPEED

This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, forms EDB's and then SR's. It then prints the CTOF speed, the time, and CTOF_STATUS_LEN provided that CTOF speed is not 25.0 km/s. This program does not span files.

DUMMY

This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, looking for dummy EDB's. Data from Dummy EDB's is stored in a huge array. Portions of that data (MTOF classification tables, levels and other mode-specific information, voltage steps, etc.) are interpreted, then displayed. The output file DUMMY.TABLE contains roughly 1 page per 8 hour period.

DUMP_PACKET

This program dumps the time and the source sequence counter for each packet. If a sync word is present that is dumped as well. The output file PACKET.DAT contains one line per packet. This program does not span files.

DUMP_TIMES

This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, forms EDB's and then SR's. It then dumps the packet times for each EDB 0, the SR start time from D_Spare, and the difference between them. The output file TIMES.DAT contains a few lines per science record. This program does not span files.

EDB

This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, forms EDB's and then SR's. It can dump each science record to EDB.TABLE, producing 1 page per 15 seconds, or it can dump the information to a binary file suitable for use on a Mac, or it can do both. If the input file is an LZ file, the binary file is named YY_DOY_MMDD.BIN. If the input file is an REL/QKL file the binary file is named YY_DOY_MMDDHH.BIN. In both cases, the year, day of year, month, and day specified by YY, DOY, MM, and DD come from the input file name, as does the hour, specified by HH in the latter case.

EDBPM

This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, forms

	EDB's and then SR's. It dumps the information to a binary file, together with solar wind parameters calculated from the data. If the input file is an LZ file, the binary file is named YY_DOY_MMDD.BIN. If the input file is an REL/QKL file the binary file is named YY_DOY_MMDDHHP.BIN. In both cases, the year, day of year, month, and day specified by YY, DOY, MM, and DD come from the input file name, as does the hour, specified by HH in the latter case.
HEAT_CURR	This program dumps currents and heater status from SVM HK1. It can deal with faulty times (caused, e.g., by a satellite reset) by checking if the year of the first packet is before the launch date (1995). If so the starting Epoch time is set to zero (early 1958), and the ending Epoch time is left at its current value (usually the current date). As a result, files are still spanned, but every file header is printed - not just the header of the first data file, as usual. The output file is HEAT_CURR.DAT.
HK	This program opens a CELIAS housekeeping file from disk or CD, reads and dumps the file header, and then reads and dumps HK packets. It prints only a few quantities (voltages, currents, temperatures, and a few others), and prints them in a column format to facilitate the use of KaleidaGraph. The output file is named HK.DAT, and can only be printed using the MP4 command (its output is 148 columns across!).
HK_FULL	This program opens a CELIAS housekeeping file from disk or CD, reads and dumps the file header, and then reads and dumps HK packets. The output file, named HK.TABLE, will contain one page per 15 seconds.
HK_MINMAX	This routine finds the two lowest values, the two highest values, and the average for DPU and MTOF-related quantities from the Celias Housekeeping files. It operates on a single LZ file and does not span files. Its output is written to the file HK_MINMAX.DAT.
HOUR_AVERAGE	This program reads the data files produced by PMSW at 5 minute resolution and generates 1 hour and 2 hour resolution files. These files have the same name as the input file, but with the extents .1HR and .2HR, respectively. The version of HOUR_AVERAGE in [SOHO.EXE] reads files with 8 columns of data, exclusive of the date and time. The version in [SOHO.TEST] reads files with 12 columns of data exclusive of the date and time.
LOG_SOHO_POSITION	This program reads a predicted or definitive SOHO orbit CDF file and extracts several quantities at just after midnight. It then appends these to the file ORBIT.DAT in the directory [SOHO]. The quantities extracted from the orbit file are: GSE position (X, Y, and Z), printed in Earth radii; Space latitude and longitude, printed in degrees; and Carrington Rotation Number (earth). The program, when run, prompts the user for an orbit (OR) filename. These files are located in a directory pointed to by the logical names SOHO_OR_DATA and OR.
PHATREND	This program allows the user to select up to 10 TOF regions and an interval of summation. It then counts the number of PHA words with TOF's in each region, and outputs the result along with the input file header to a file named PHATREND.DAT. If the regions overlap then an event may be counted more than once. If a file named PHATREND.INPUT exists in the default directory then inputs will be read from it.

PMRATES	This program dumps all six PM rates and PM E/Q values in a column format readable by KaleidaGraph. The output file is named PMRATES.DAT.
PMRSTACK	This program generates stacked plots of the PM counts vs. radius on either logarithmic or linear scales. The output file is named PMRSTACK.DAT.
PMRSTACKA	This program generates stacked plots of the PM counts vs. radius on either logarithmic or linear scales. A different binning scheme than the original is used. The output file is named PMRSTACK.DAT.
PMRT	This program dumps the distributions in radius and theta of PM counts. The output file is named PMRT.TABLE.
PMSIMEOF	This program (formerly named TABLE_PM_E) prompts the user for six PM rates. It then calculates the solar wind speed, density, and thermal speed using the same algorithm as PMSWA.
PMSW	This program fits PM data and derives solar wind speed, density, thermal speed, and N/S angle. The output file is named PMSW.DAT. The most recent version (in [SOHO.EXE]) produces 23 columns of output.
PMSW_REFORMAT	This program reads a file produced by PMSW and reformats it, printing out solar wind speed, density, thermal speed, and flow angle, along with orbital data from the CDF files. Definitive orbit data are used when available; Predictive orbit data are used when necessary. The output file may be either HTML or plain text, as the user desires. The user chooses both the output file's name and its format.
RATES	This program opens a CELIAS science data file from disk or CD, reads and dumps the file header, and then reads science data packets, forms EDB's and then SR's. It then dumps only the rates, printing them in a column format to facilitate their use in KaleidaGraph. The output file is named RATES.DAT and can only be printed using the command MP4 (its output is 168 columns across!).
SAMPLE_SW_SMS	This program samples all files of the form SW_96xxx.DAT (where xxx is a day of year) in the directory SMS1:[COLLIER.SW_SPEED]. Every 20th proton speed is printed out (along with its corresponding time) to the file SMS_SPEED.DAT.
SPLIT_QKL	This program scans the EOF directory for SOHO Quicklook (*.QKL) files. For each QKL file the program reads the file and determines if it contains a large time gap. If so the QKL file is split into two smaller QKL files: the first has all the data up to the start of the gap, and the second has all data after the gap. The output files are appropriately named to reflect their start times and are given a file type of .MOD . If the amount of data in the first output would be less than a certain threshold, typically five minutes, it is not created and only the second file is created. If there is no gap or the gap is fairly short a copy of the entire file is made; the new file is given a file type of .MOD . In either case, after the copy operation(s) is complete, the input file is moved to another directory. Both the minimum length (in time) of the first data segment and the size of the time gap are parameters which can be easily changed. They are currently set at 5 minutes and 30 minutes, respectively.

STACK	Not technically a program, STACK is a DCL command file that prompts the user for input and then invokes PMRSTACK, invokes PMRSTACKA, or uses a preexisting file generated by an earlier invocation of these programs to produce a stacked plot.
SWE_AVERAGE	This program reads the SWE KP files at 90 second resolution and generates 1 hour and 6 hour resolution files. These files have the same name as the input file, but with the extents .1HR and .6HR, respectively.
THERM2	This program dumps temperatures from SVM HK2. It uses a polynomial fit. This program can deal with faulty times (caused, e.g., by a satellite reset). When s/c times erroneously indicate a year before 1995, files are still spanned, but every file header is printed - not just the header of the first data file, as usual. The output file is THERM2.DAT.
THERM4	This program dumps temperatures from SVM HK4. It uses a polynomial fit. This program can deal with faulty times (caused, e.g., by a satellite reset). When s/c times erroneously indicate a year before 1995, files are still spanned, but every file header is printed - not just the header of the first data file, as usual. The output file is THERM4.DAT.

Appendix D: List of Publications Relevant to the CELIAS Instrument

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Talks and Poster Presentations

Model for the Mass Fractionation in the January 6, 1997, CME
Wurz, P., Bochsler, P., and Lee, M. A., 1999 Fall AGU in California, USA.

Determination of the argon isotopic ratio of the solar wind using SOHO/CELIAS/MTOF
J.M. Weygand, F.M. Ipavich, P. Wurz, J. A. Paquette, and P. Bochsler, 8th SOHO Workshop in Paris, France.

Magnesium Isotopic Abundance in the Slow and Coronal Hole Associated Solar Wind: SOHO/CELIAS/MTOF Measurements. H. Kucharek, F.M. Ipavich, R. Kallenbach, B. Klecker, H. Grünwaldt, M. R. Aellig, and P. Bochsler, 8th SOHO Workshop in Paris, France.

Elemental and ionic composition of suprathermal ions in the May 2-3, 1998 CME
K. Bamert, R.F. Wimmer-Schweingruber, R. Kallenbach, M. Hilchenbach, B. Klecker, A. Bogdanov, 1999 Spring AGU in Boston, U.S.A.

Magnesium isotopic abundance in slow and coronal hole associated solar wind: SOHO/CELIAS/MTOF measurements, H. Kucharek, F. M. Ipavich, R. Kallenbach, B. Klecker, H. Gruenwaldt, M. R. Aellig, P. Bochsler, Spring AGU 1999 in Boston, USA

Determination of the argon isotopic ratio of the solar wind using SOHO/CELIAS/MTOF
J.M. Weygand, F.M. Ipavich, P. Wurz, J.A.Paquette, and P. Bochsler, 1999 Spring AGU in Boston, U.S.A.

Determination of the argon isotopic ratio of the solar wind using SOHO/CELIAS/MTOF
J.M. Weygand, F.M. Ipavich, P. Wurz, J.A.Paquette, and P. Bochsler, EGS Conference in Den Haag Netherlands, 1999.

Elemental and Ionic Composition of Suprathermal Ions in the May 2-3, 1998 CME
K. Bamert, R.F. Wimmer-Schweingruber, R. Kallenbach, M. Hilchenbach, B. Klecker, A. Bogdanov, EGS Conference in Den Haag, Netherlands, 1999.

Isotopic Composition of Magnesium Measured with SOHO/CELIAS/MTOF In Slow and

Coronal Hole Associated Solar Wind, H. Kucharek, F. M. Ipavich, R. Kallenbach, B. Klecker, H. Grünwaldt, M. R. Aellig, and P. Bochsler, the 24th General Assembly in Den Hague, Netherlands, April 19-23, 1999.

Nonlinear Analysis of Solar Wind Data from the Proton Monitor Onboard SOHO, R. Sachs, H. Kucharek, F. M. Ipavich, R. Kallenbach, B. Klecker, and P. Bochsler, the 24th General Assembly in Den Hague, Netherlands, April 19-23, 1999.

The Si/O Abundance Ratio in the Solar Wind Measured with CELIAS/CTOF and the Search for the FIP Effect in Coronal Hole Associated Wind. M.R. Aellig, H. Holweger, S. Hefti, P. Wurz, H. Grünwaldt, F.M. Ipavich, and P. Bochsler, the AGU fall meeting 1998.

The Iron, Silicon, and Oxygen Abundance in the Solar Wind Measured with SOHO/CELIAS/MTOF, P. Wurz, M.R. Aellig, F.M. Ipavich, S. Hefti, P. Bochsler, and A.B. Galvin, the AGU fall meeting 1998.

Isotopic Composition of Solar Wind Nitrogen: First In-Situ Determination by CELIAS/MTOF Onboard SOHO R. Kallenbach, J. Geiss, F. M. Ipavich, G. Gloeckler, P. Bochsler, F. Gliem, S. Hefti, M. Hilchenbach, and D. Hovestadt, the AGU fall meeting 1998.

The Fe/O Elemental Abundance Ratio in the Solar Wind, M.R. Aellig, P. Bochsler, P. Wurz, H. Grünwaldt, S. Hefti, H. Holweger, F.M. Ipavich, and B. Klecker, the Solar Wind 9 Conference in Nantucket, MA, USA, 5-9 October 1998.

CELIAS/CTOF Measurement of O^{5+}: A Key to the Maze of Coronal Electron Velocity Distribution, H. Grünwaldt, M. Hilchenbach, E. Marsch, P. Bochsler, and F. Ipavich Solar Wind 9 Conference in Nantucket, MA, USA, 5-9 October 1998.

Highly unusual behavior of Solar Wind heavy ions in early May 1998, F. M. Ipavich, G. Gloeckler, J. Paquette, T. Zurbuchen, P. Bochsler, P. Wurz, Solar Wind 9 Conference in Nantucket, MA, USA, 5-9 October 1998.

First Measurements of Sulfur Isotopes in the Solar Wind, A.B. Galvin, F.M. Ipavich, J. Paquette, R. Kallenbach, B. Klecker, and P. Wurz, Solar Wind 9 in Nantucket, MA, USA. 5-9 October 1998.

SOHO/CELIAS Measurements of Sulfur Isotopes in the Solar Wind, A.B. Galvin, F.M. Ipavich, J. Paquette, D. Hovestadt, P. Wurz, and R. Kallenbach, 7th SOHO Workshop, 28 September - 1 October 1998, Northeast Harbor, Maine, USA.

Temporal Behavior of Solar Wind Fe and O in High Speed Stream Onsets, F. M. Ipavich, G. Gloeckler, T. Zurbuchen, S. Hefti, P. Bochsler, L. A. Fisk, R. Kallenbach, J. Paquette, and R. F. Wimmer-Schweingruber, 7th SOHO Workshop, 28 September - 1 October 1998, Northeast Harbor, Maine, USA.

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Multispacecraft Analysis of a ^{3}He Rich Solar Energetic Particle Event with ACE/SEPICA and SOHO/HSTOF, A.T. Bogdanov, E. Möbius, B. Klecker, M. Hilchenbach, D. Hovestadt, L.M. Kistler, M.A. Popecki, E.J. Lund, D. Heirtzler, A.B. Galvin, P. Bochsler, H. Grünwaldt, F.M. Ipavich, and F. Gliem, AGU Spring Meeting, 26-29 May 1998, Boston, MA, USA.

Fractionation of Si, Ne, and Mg Isotopes in the Solar Wind as Measured by SOHO/CELIAS/MTOF, R. Kallenbach, F.M. Ipavich, H. Kucharek, P. Bochsler, J. Geiss, F. Gliem, G. Gloeckler, H. Grünwaldt, M. Hilchenbach, and D. Hovestadt, AGU Spring Meeting, 26-29 May 1998, Boston, MA, USA.

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Pickup Ions in the Mass Interval 20-30 AMU Observed with SOHO/CELIAS/CTOF vs. Model Calculations of Distribution Functions Accounting for Heliospheric and Interstellar Seed Populations, A.T. Bogdanov, B. Klecker, D. Hovestadt, H. Grünwaldt, M. Hilchenbach, E. Möbius, F. M. Ipavich, F. Gliem, P. Bochsler, at AGU Fall Meeting, 8-12 December 1997, San Francisco, CA, USA.

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